MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2019 / 2020

EME1026 – FLUID MECHANICS

(ME)

16 OCTOBER 2019

9:00 a.m. – 11:00 a.m.

(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 5 pages, including the cover page with 4 Questions only.

2. Attempt **ALL** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

A converging nozzle of 5.0 cm inlet diameter (see Figure Q1) is attached to the end of a 5.0 cm diameter horizontal pipeline in which an incompressible fluid, of 1.0×10^3 kg/m^3 density and negligible viscosity, is flowing steadily. The fluid enters the nozzle with a velocity of 6 m/s; it leaves the nozzle with a velocity of 18 m/s and discharges into the surrounding atmosphere, where the pressure is 100 kPa. The nozzle has been designed in such a way that the fluid velocity varies linearly with distance along its axis; i.e.,

$$u = mx + n$$

where u is the fluid velocity and x denotes the axial distance from the nozzle's inlet, m and n being two positive constants.

(a) Determine the mass flow rate of the fluid.

[3 marks]

(b) Determine the fluid acceleration at points A, B, and C.

[6 marks]

(c) Determine the resultant force (i.e., its magnitude and direction) exerted by the inner wall of the nozzle on the fluid contained instantaneously inside the nozzle.

[10 marks]

(d) Determine the resultant force (i.e., its magnitude and direction) exerted by the nozzle on the pipe.

[6 marks]

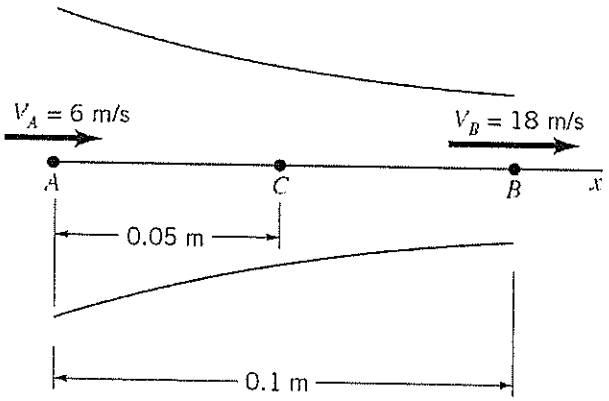

Figure Q1.

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Question 2

A certain gas, of $1.23\,\mathrm{kg/m^3}$ density and $1.46 \times 10^{-5}\,\mathrm{m^2/s}$ kinematic viscosity, is to flow in a smooth pipeline of diameter $D = 0.1\,\mathrm{m}$ with a mean velocity of $15\,\mathrm{m/s}$. The design of the pipeline system requires the knowledge of the axial pressure gradient associated with this flow specification. To this end, you are to determine the pressure drop of the gas over a 1 m section of the pipeline by assuming a fully developed flow and carrying out the following steps.

(a) Determine the Reynolds number Re_D, and confirm that the flow is turbulent.

[6 marks]

(b) Using the formula

$$\sqrt{f} = \frac{1}{1.8\log_{10}(\mathrm{Re}_D) - 1.51}$$

for a fully developed turbulent flow in a smooth pipe, determine the value of the Darcy friction factor f.

[2 marks]

(c) Determine the shear stress at the pipe wall, τ_w, using the result obtained in part **(b)**.

[6 marks]

(d) Using the result obtained in part **(c)**, determine the pressure drop of the gas, Δp, over a pipe section of length $\Delta L = 1.0\,\mathrm{m}$.

[11 marks]

Continued...

Question 3

The power, P, to drive an axial pump is in a function of density of fluid, ρ, volumetric flow rate, Q, pump head, h, diameter of rotor, D, and angular speed of rotor, N.

(a) Verify that $\frac{P}{\rho D^5 N^3}$ is a dimensionless group. **[10 marks]**

(b) Determine the remaining pi group and perform dimensional analysis. **[10 marks]**

(c) Define geometric similarity and dynamic similarity. Categorize the pi group obtained from part **(b)** as geometric similarity or dynamic similarity, respectively. **[5 marks]**

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Question 4

The radial component of velocity of water leaving a centrifugal pump is 15 m/s. The magnitude of the absolute velocity of water at the pump exit is 30 m/s. Water enters the pump rotor radially. The pump has inner impeller radius of 0.05 m and outer impeller radius of 0.2 m. The impeller rotates at 2000 rpm.

(a) Sketch the velocity triangle diagrams at the inlet and the exit of the centrifugal pump. Label each velocity vector clearly. Define **U** as absolute velocity of blade, **V** as absolute velocity of water, **W** as relative velocity of water. **[6 marks]**

(b) Determine the absolute velocity of blade at the inlet and the exit of the centrifugal pump. **[4 marks]**

(c) Determine the tangential component of velocity at the inlet and the exit of the centrifugal pump. **[4 marks]**

(d) Determine the radial component of velocity at the inlet of the centrifugal pump. **[4 marks]**

(e) Determine the relative velocity of water at the inlet and the exit of the centrifugal pump. **[7 marks]**

End of Paper